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Attn: Dr. T.L.K. Smull
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I. INTRODUCTION

This report summarizes the work carried out during the past six months on the study of electromagnetic scattering from rough surfaces, with emphasis on the lunar surface. The principal areas of investigation have been (1) theoretical studies of electromagnetic scattering from statistically rough surfaces and (2) reduction and analysis of data obtained during the past year.

The work during this period was greatly slowed due to an interruption in funding, which was remedied only very recently.

II. THEORETICAL STUDIES

Efforts were continued toward expanding present theories of scattering from statistically rough surfaces. These studies have been based on the improved theory developed during the past year and listed in References 1 through 4. The emphasis has been on considerations of the depolarization of waves incident on a rough surface. The depolarized component of radar return is not predicted at all by most former scattering theories and is inaccurately estimated by others, but it has been shown experimentally not only to exist but to be a very sensitive indication of the roughness characteristics of the scattering surface.

Also under study are the effects of surface slope and dielectric constant on the total cross-section of the moon, and the theoretical estimation of the lunar surface bistatic scattering pattern. Results of these studies would find application in the interpretation of radiometer experiments.

III. DATA ANALYSIS

A part of the CW S-band data collected during the past year has been digitized and is being analyzed. Both direct- and cross-polarized data are available; from these can be obtained estimates of the effective dielectric constant, the rms surface slope, and the total cross-section of the moon. High stability was maintained in both the transmitting and the receiving systems, making possible resonably accurate determination of the lunar scattering coefficient as a function of angle incidence.

IV. PROPOSED PROGRAM FOR THE REMAINDER OF THE GRANT (1 May 1966 to 31 October 1966)

During the remainder of the grant, the data which have already been collected will be analyzed by digital methods. Included will be the continued analysis of the doppler data to determine the rms surface roughness and the depolarizing characteristics of the lunar surface. An attempt to verify the theory of the two-frequency experimental method will be made by analyzing the presently available two-frequency data. The theoretical investigation of the relationship of the depolarization characteristics, bistatic pattern, and total scattering cross-section to the dielectric constant and mean slope of statistically rough surfaces will be continued, with emphasis on defining electromagnetic experiments for obtaining information on the surface of the moon or planets from a considerable distance.

Studies will be conducted of the feasibility of using the methods developed under this grant in conjunction with a planetary probe vehicle. For instance, the possibility of conducting a radar experiment entirely from the vehicle will be compared with the possibility of using the vehicle as one terminal (either transmitting or receiving) of the radar system (with the planet as the target) while the other terminal is on the earth. Both of these will be compared with the system which uses an earth terminal as both the radar transmitter and radar receiver. The important consideration here is not merely convenience or signal-to-noise ratio, but the information contained in bistatic scattering by rough surfaces, as opposed to backscattering.

V. PROPOSED FUTURE PROGRAM FOR THE PERIOD 1 NOVEMBER 1966 TO 31 OCTOBER 1967

Assuming that the studies to be conducted later this year indicate that the use of a flyby probe for making bistatic scattering measurements

of planetary surface would yield important information, it will then be necessary to further develop our understanding of bistatic scattering and depolarization from rough surfaces. This is only poorly developed at the present time and should be expanded, both theoretically and experimentally, in order to determine what planetary surface characteristics could be measured by this technique and the best parameters to choose for the experiment.

After further refinement of the two-frequency method of measuring surface roughness, some additional two-frequency lunar backscatter data should be acquired using the improved Antenna Laboratory facility. These additional data are necessary to verify whether this experiment conforms, in practice, to the theoretical analysis developed for it. The completion of this experimental work would also be used to test the validity of the physical-optics approximation, as applied to theoretical studies of rough surfaces for the case of the lunar surface at X-band.

In order to undertake this proposed future program supplemental funding will be required.

VI. REFERENCES

1. Barrick, D.E., "Two Experiments Yielding Lunar Surface Information Employing Polarized Radar Waves," Report 1388-17, 15 August 1965.

2. Barrick, D.E., "A More Exact Theory of Backscattering from Statistically Rough Surfaces," Report 1388-18, 31 August 1965.

3. Barrick, D.E., "Determination of RMS Height of a Rough Surface Using Radar Waves," Report 1388-19, 31 August 1965.

4. Barrick, D.E., "Theoretical Curves of Backscattering Cross-Sections of Rough Surfaces for Several Polarization States Using Two Statistical Models," Report 1388-20, 31 August 1965.

5. 1388 Semi-Annual Report for period 1 October 1964 - 30 April 1965.

6. 1388 Semi-Annual Report for period 1 May 1965 - 31 October 1965.